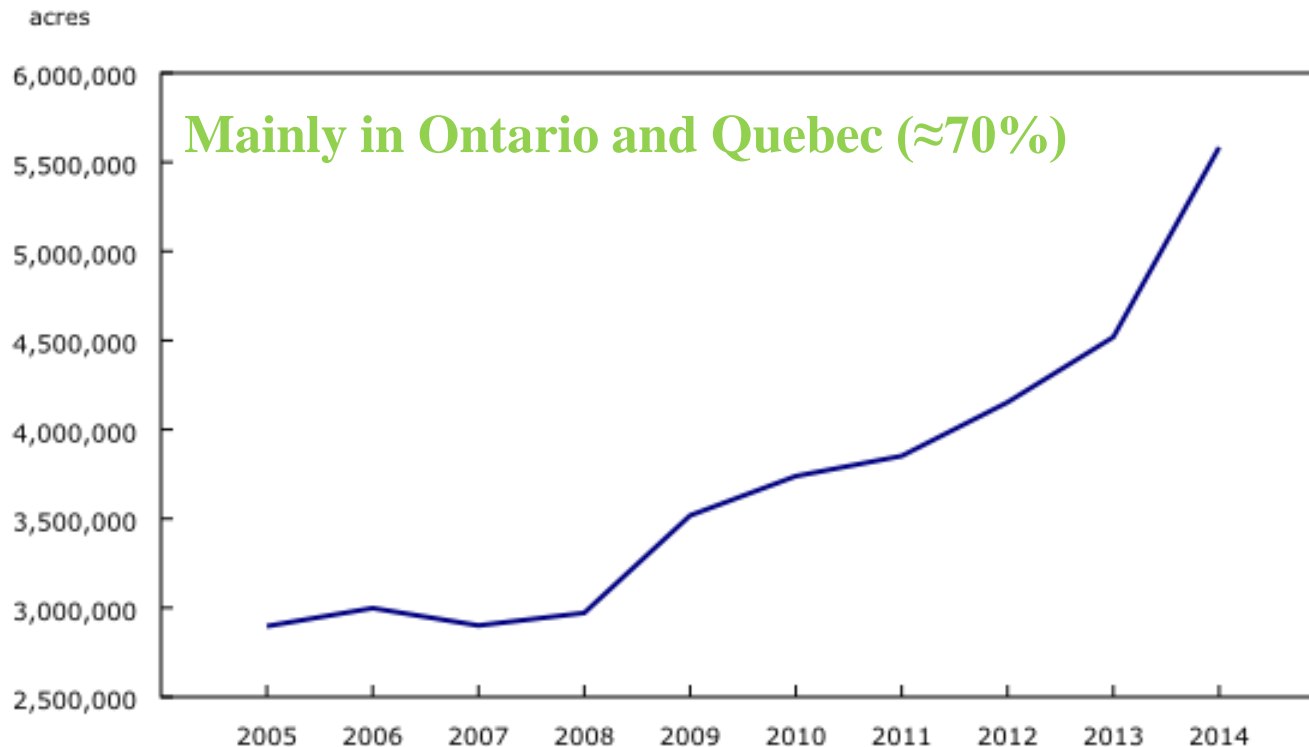




## Nutrient uptake, N fixation and release from soybean pea and lentil in Saskatchewan soils

Jing Xie, Jeff Schoenau, Tom Warkentin

## Canadian national soybean acreage, 2005 to 2014 (Statistics Canada)



### In Saskatchewan:

- 2013: 170,000 acres
- 2014: 300,000 acres
- 2015: 335,000 acres

**Saskatchewan has become Canada's fourth-largest soybean producer.**

## Objectives

- To quantify the nutrient uptake by short-season soybean varieties and their impacts on the yield and nutrition of succeeding crops, in comparison to pea and lentil, under Saskatchewan growing conditions;
- To quantify the N fixation of soybean, pea, and lentil;
- To reveal nutrient release and cycling through the soil-plant system to following crops in rotation.

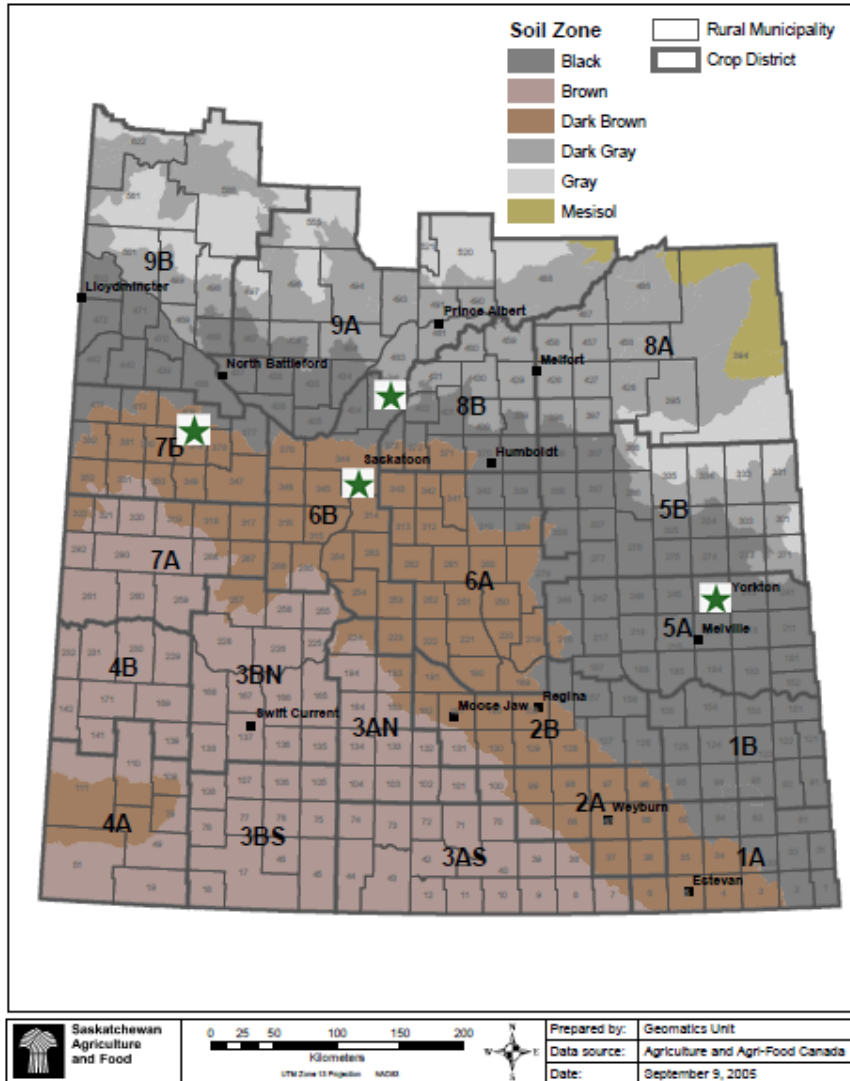


# **This presentation will discuss:**

- Yield, N and P uptake of soybean, pea, and lentil at four Saskatchewan site locations in 2014;
- N fixation by soybean, pea, and lentil;
- Yield, N and P uptake of wheat grown on stubble the following year



## Soil Zones of Saskatchewan



## Four site locations:

- Saskatoon (Dark Brown)
- Scott (Dark Brown)
- Rosthern (Black)
- Yorkton (Black)

## Two field seasons:

- 2014 (Soybean, lentil, pea)
- 2015 (Spring wheat)

## Experimental design:

- Randomized complete block design (RCBD)

## Crop varieties used in the 2014-2015 field season

| Crop    | Variety        | Market class | Breeder            | Herbicide resistance | Variety code |
|---------|----------------|--------------|--------------------|----------------------|--------------|
| pea     | CDC Meadow     | yellow       | CDC                | group 2              | P-1          |
| pea     | CDC Amarillo   | yellow       | CDC                | group 2              | P-2          |
| pea     | CDC Limerick   | green        | CDC                | group 2              | P-3          |
| lentil  | CDC Impower    | large green  | CDC                | group 2              | L-1          |
| lentil  | CDC Invincible | small green  | CDC                | group 2              | L-2          |
| lentil  | CDC Maxim      | small red    | CDC                | group 2              | L-3          |
| soybean | P001T34R       | oilseed      | Pioneer Dupont     | group 2              | S-1          |
| soybean | TH3303R2Y      | oilseed      | Thunder            | group 2              | S-2          |
| soybean | NSC Moosomin   | oilseed      | Northstar Genetics | group 2              | S-3          |
| wheat   | CDC Abound     | hard red     | CDC                | group 2              | W            |

**One variety of each crop was evaluated using nitric acid digestion methods, including:**

| <b>Crop</b> | <b>Variety</b> | <b>Market class</b> | <b>Breeder</b> | <b>Herbicide resistance</b> |
|-------------|----------------|---------------------|----------------|-----------------------------|
| pea         | CDC Meadow     | yellow              | CDC            | group 2                     |
| lentil      | CDC Maxim      | small red           | CDC            | group 2                     |
| soybean     | TH3303R2Y      | oilseed             | Thunder        | group 2                     |



## 15-N study at the Rosthern site:

- Form:  $(^{15}\text{NH}_4)(^{15}\text{NO}_3)$  with the enrichment of 10%
- Rate:  $20 \text{ kg N ha}^{-1}$
- Timing: 5<sup>th</sup> leaf stage (pea/lentil) and 1<sup>st</sup> trifoliate leaf stage (soybean)





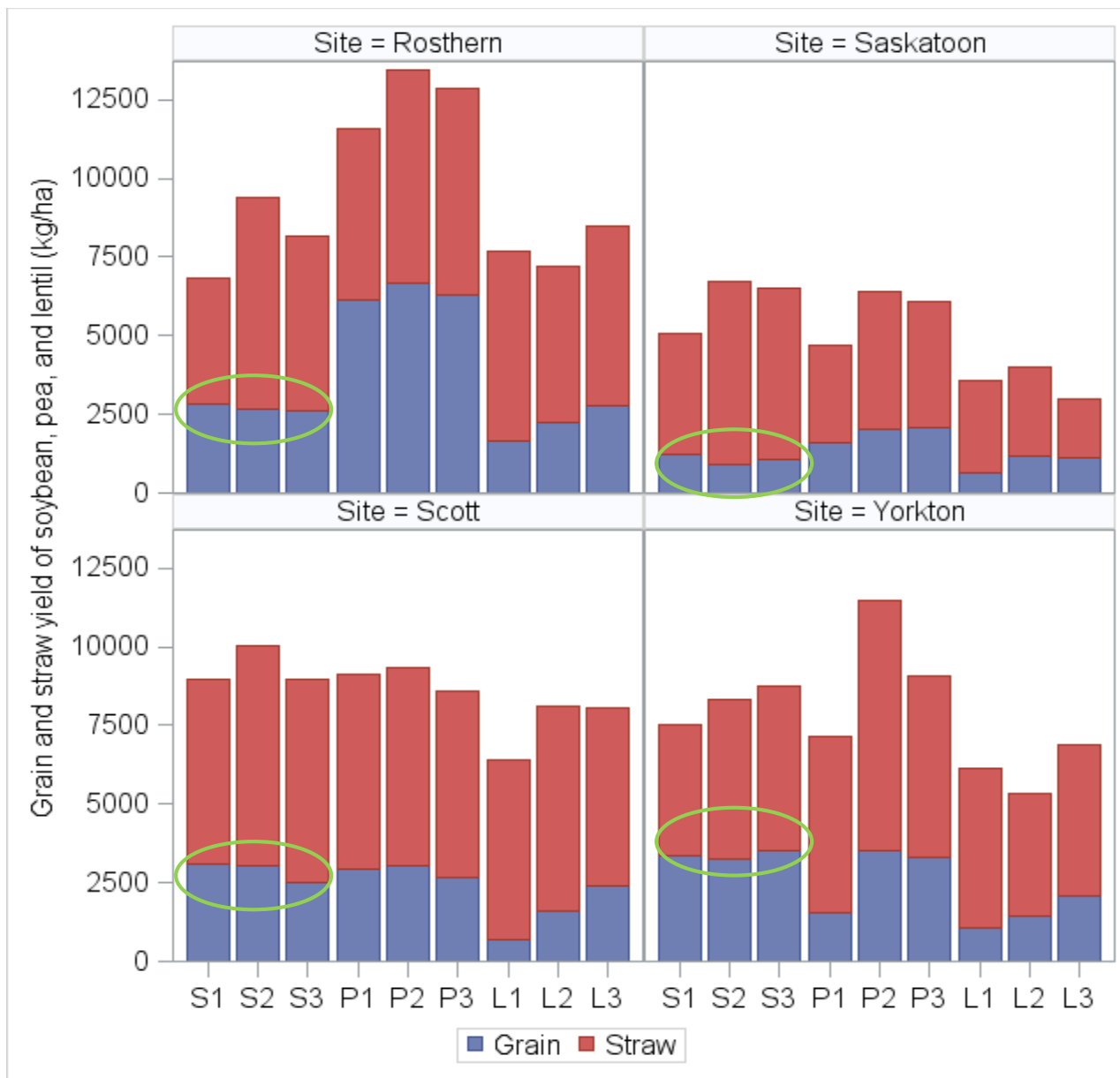




A photograph of a field with rows of green legume plants, likely soybeans, peas, and lentils. The plants are in various stages of growth, with some showing trifoliate leaves and others more mature. White plastic mulch is visible between the rows. In the background, a blue car is parked on the left, and a line of trees is visible under a cloudy sky.

**Yield, N and P uptake in soybean, pea, and lentil**





S1- P001T34R  
 S2- TH3303R2Y  
 S3- NSC Moosomin  
 P1- CDC Meadow  
 P2- CDC Amarillo  
 P3- CDC Limerick  
 L1- CDC Impower  
 L2- CDC Invincible  
 L3- CDC Maxim

**Grain and straw yields of soybean, pea, and lentil in 2014.**

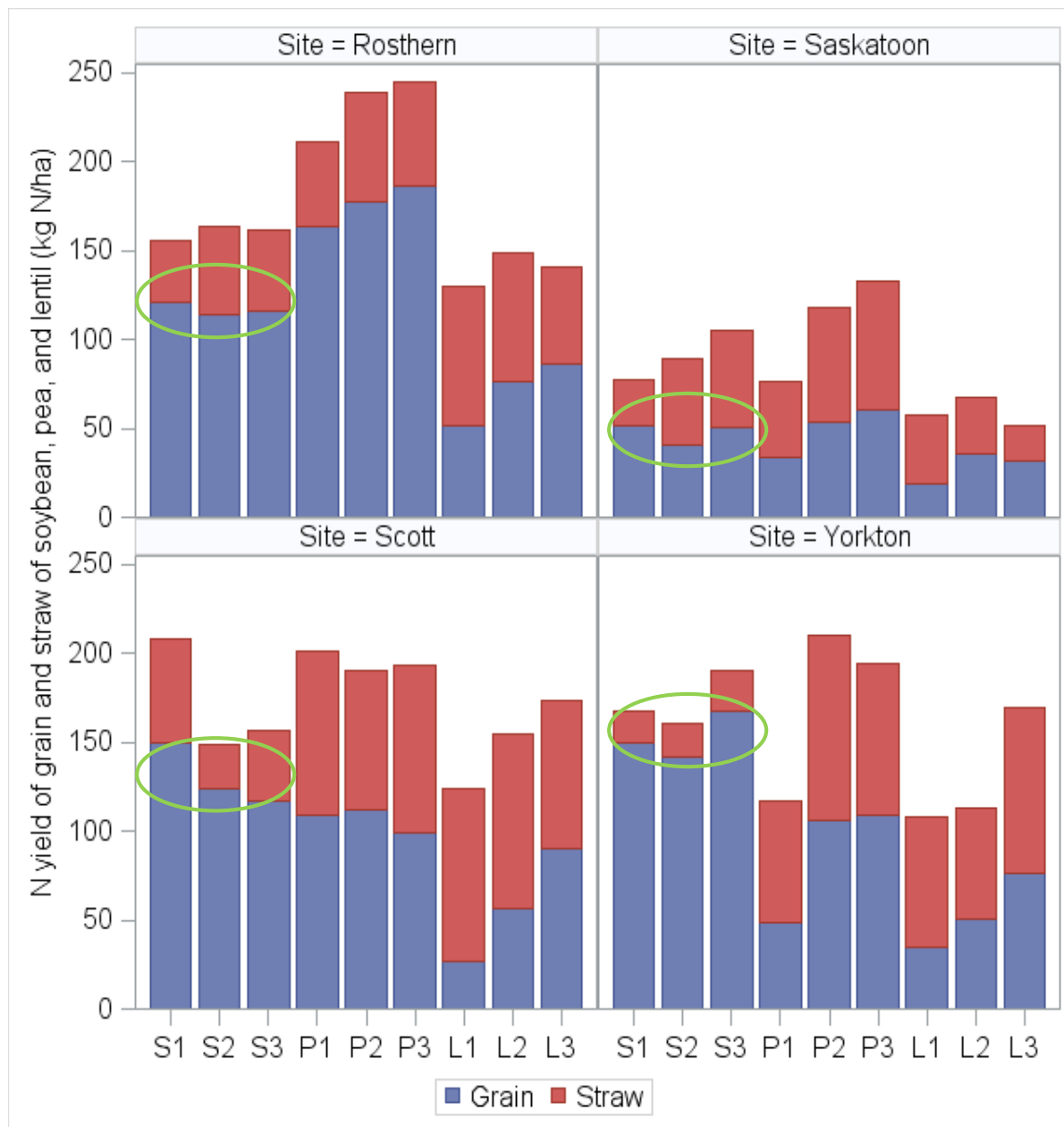


## N and P concentration in soybean, pea, and lentil in 2014 (2-1).

| Site      | Crop    | Variety        | N concentration      |         | P concentration      |         |
|-----------|---------|----------------|----------------------|---------|----------------------|---------|
|           |         |                | Grain                | Straw   | Grain                | Straw   |
|           |         |                | g N kg <sup>-1</sup> |         | g P kg <sup>-1</sup> |         |
| Rosthern  | Soybean | P001T34R       | 43.1 a               | 8.6 a   | 5.5 a                | 0.8 c   |
|           |         | TH3303R2Y      | 43.0 a               | 7.4 a   | 5.7 a                | 1.0 bc  |
|           |         | NSC Moosomin   | 44.5 a               | 8.2 a   | 5.7 a                | 0.9 bc  |
|           | Pea     | CDC Meadow     | 26.7 d               | 8.7 a   | 3.2 c                | 0.6 c   |
|           |         | CDC Amarillo   | 26.7 d               | 9.1 a   | 3.3 c                | 0.6 c   |
|           |         | CDC Limerick   | 29.7 cd              | 8.9 a   | 3.7 bc               | 0.6 c   |
|           | Lentil  | CDC Impower    | 30.4 c               | 12.9 a  | 4.1 b                | 1.5 ab  |
|           |         | CDC Invincible | 34.4 b               | 14.1 a  | 4.1 b                | 1.8 a   |
|           |         | CDC Maxim      | 31.4 bc              | 9.1 a   | 3.9 b                | 1.1 abc |
| Saskatoon | Soybean | P001T34R       | 41.2 a               | 7.5 b   | 5.1 abc              | 1.2 a   |
|           |         | TH3303R2Y      | 43.5 a               | 8.4 b   | 6.3 ab               | 1.5 a   |
|           |         | NSC Moosomin   | 45.9 a               | 10.1 b  | 6.8 a                | 1.6 a   |
|           | Pea     | CDC Meadow     | 19.9 c               | 13.8 ab | 3.7 c                | 1.1 a   |
|           |         | CDC Amarillo   | 26.8 bc              | 14.6 ab | 4.2 bc               | 1.1 a   |
|           |         | CDC Limerick   | 28.9 bc              | 18.0 a  | 4.4 bc               | 1.5 a   |
|           | Lentil  | CDC Impower    | 28.8 bc              | 13.0 ab | 4.2 bc               | 1.3 a   |
|           |         | CDC Invincible | 30.3 b               | 10.8 b  | 3.9 bc               | 1.2 a   |
|           |         | CDC Maxim      | 28.8 bc              | 10.7 b  | 3.7 c                | 1.0 a   |

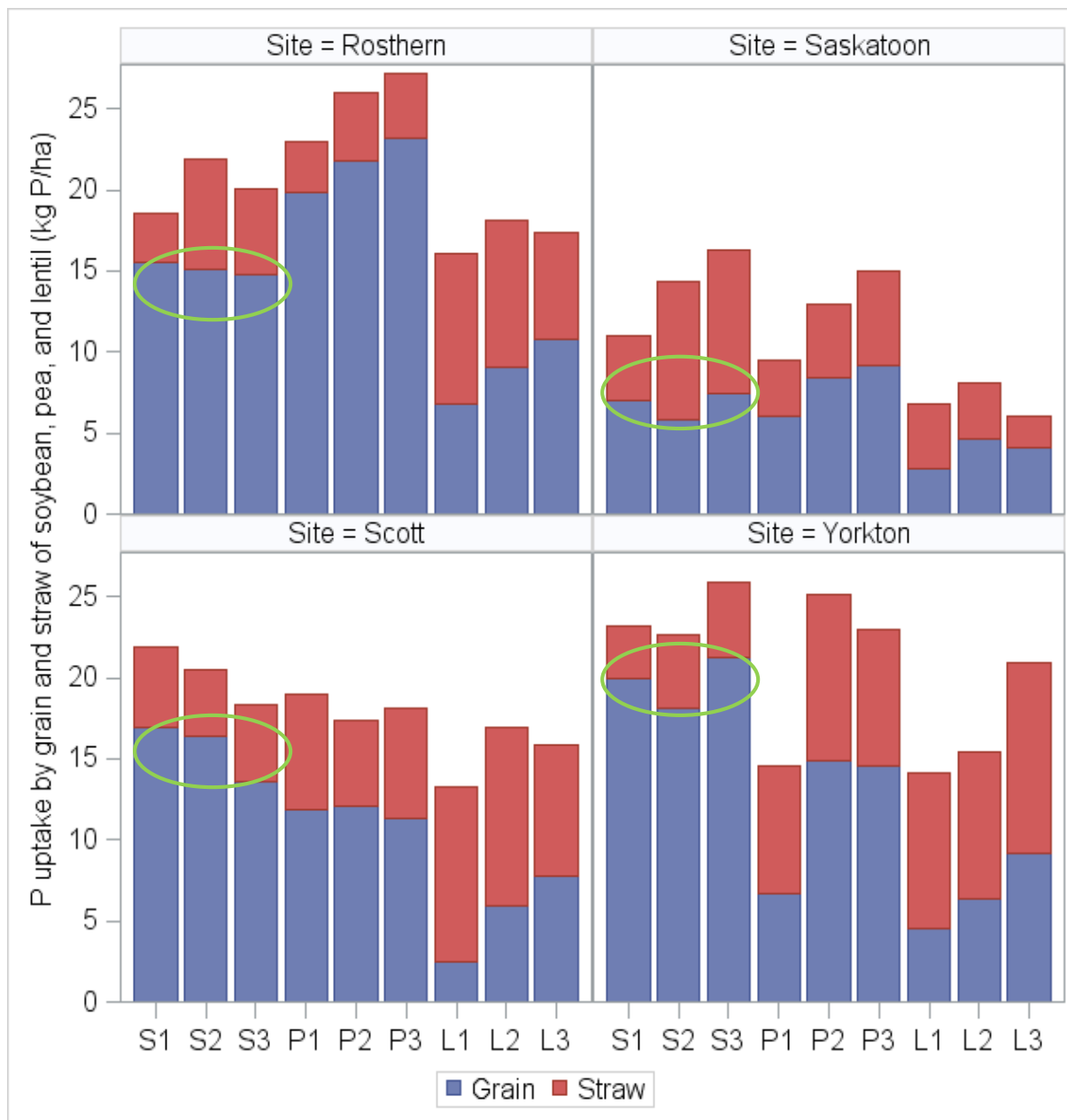
## N and P concentration in soybean, pea, and lentil in 2014 (2-2).

| Site    | Crop    | Variety        | N concentration      |         | P concentration      |         |
|---------|---------|----------------|----------------------|---------|----------------------|---------|
|         |         |                | Grain                | Straw   | Grain                | Straw   |
|         |         |                | g N kg <sup>-1</sup> |         | g P kg <sup>-1</sup> |         |
| Scott   | Soybean | P001T34R       | 47.3 a               | 9.5 abc | 5.6 a                | 0.8 bc  |
|         |         | TH3303R2Y      | 39.3 a               | 3.4 c   | 5.5 a                | 0.6 c   |
|         |         | NSC Moosomin   | 45.7 a               | 6.5 bc  | 5.4 ab               | 0.7 bc  |
|         | Pea     | CDC Meadow     | 37.4 a               | 14.9 a  | 4.0 c                | 1.2 abc |
|         |         | CDC Amarillo   | 36.9 a               | 12.8 ab | 4.0 c                | 0.9 bc  |
|         |         | CDC Limerick   | 36.7 a               | 16.0 a  | 4.3 bc               | 1.1 abc |
|         | Lentil  | CDC Impower    | 37.6 a               | 16.9 a  | 3.7 c                | 1.9 a   |
|         |         | CDC Invincible | 35.7 a               | 14.9 a  | 3.7 c                | 1.7 ab  |
|         |         | CDC Maxim      | 37.2 a               | 14.6 ab | 3.3 c                | 1.4 abc |
| Yorkton | Soybean | P001T34R       | 44.5 b               | 4.2 d   | 5.9 a                | 0.8 d   |
|         |         | TH3303R2Y      | 43.6 b               | 3.8 d   | 5.6 a                | 1.0 cd  |
|         |         | NSC Moosomin   | 47.6 a               | 4.4 d   | 6.0 a                | 0.9 cd  |
|         | Pea     | CDC Meadow     | 31.1 d               | 12.2 c  | 4.3 b                | 1.4 bcd |
|         |         | CDC Amarillo   | 30.6 d               | 13.2 bc | 4.3 b                | 1.3 bcd |
|         |         | CDC Limerick   | 33.2 cd              | 14.7 bc | 4.5 b                | 1.5 bc  |
|         | Lentil  | CDC Impower    | 32.6 cd              | 14.3 bc | 4.3 b                | 1.9 ab  |
|         |         | CDC Invincible | 35.0 c               | 16.4 ab | 4.4 b                | 2.3 a   |
|         |         | CDC Maxim      | 35.5 c               | 19.3 a  | 4.3 b                | 2.4 a   |



**N yield in the grain and straw of soybean, pea, and lentil.**



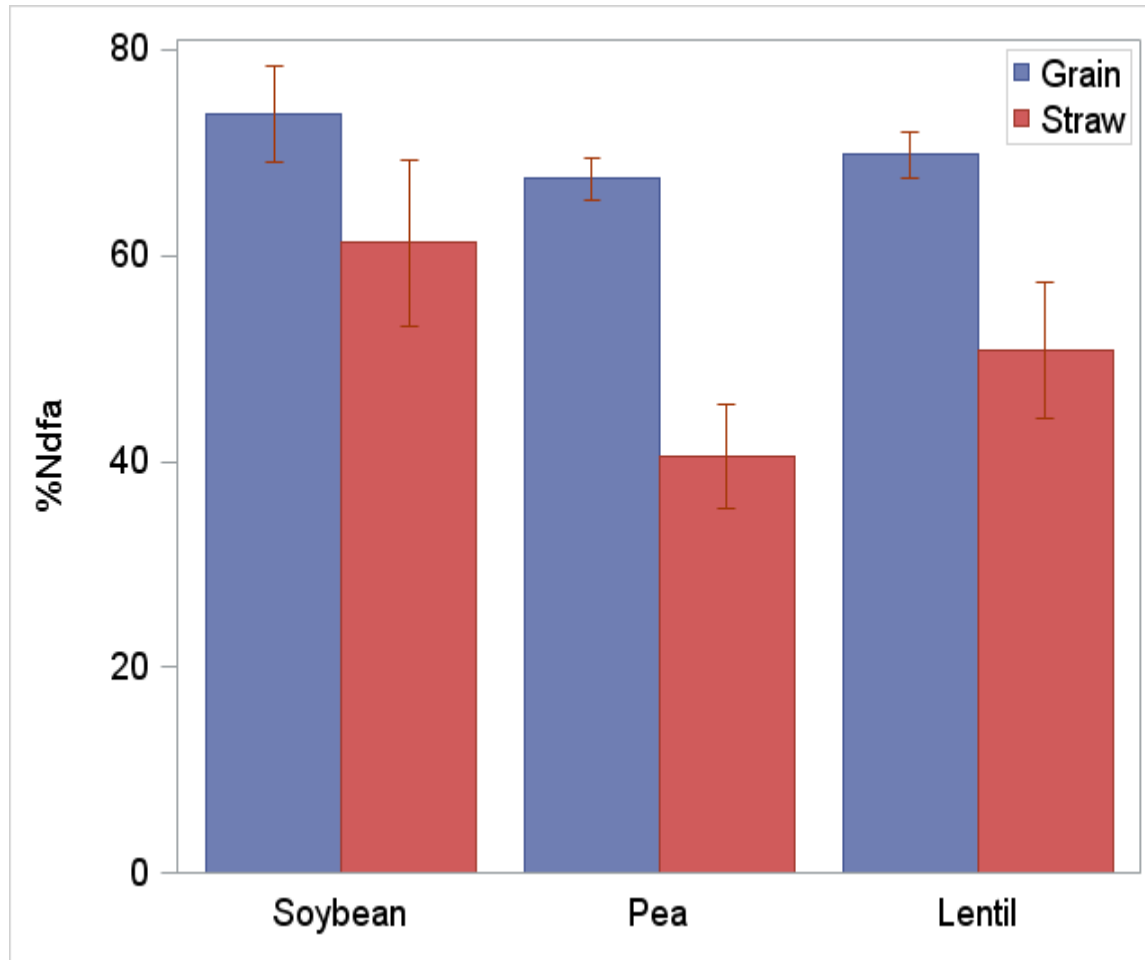


S1- P001T34R  
 S2- TH3303R2Y  
 S3- NSC Moonsomin  
 P1- CDC Meadow  
 P2- CDC Amarillo  
 P3- CDC Limerick  
 L1- CDC Impower  
 L2- CDC Invincible  
 L3- CDC Maxim

**P yield in the grain and straw of soybean, pea, and lentil.**

# N fixation by soybean, pea, and lentil



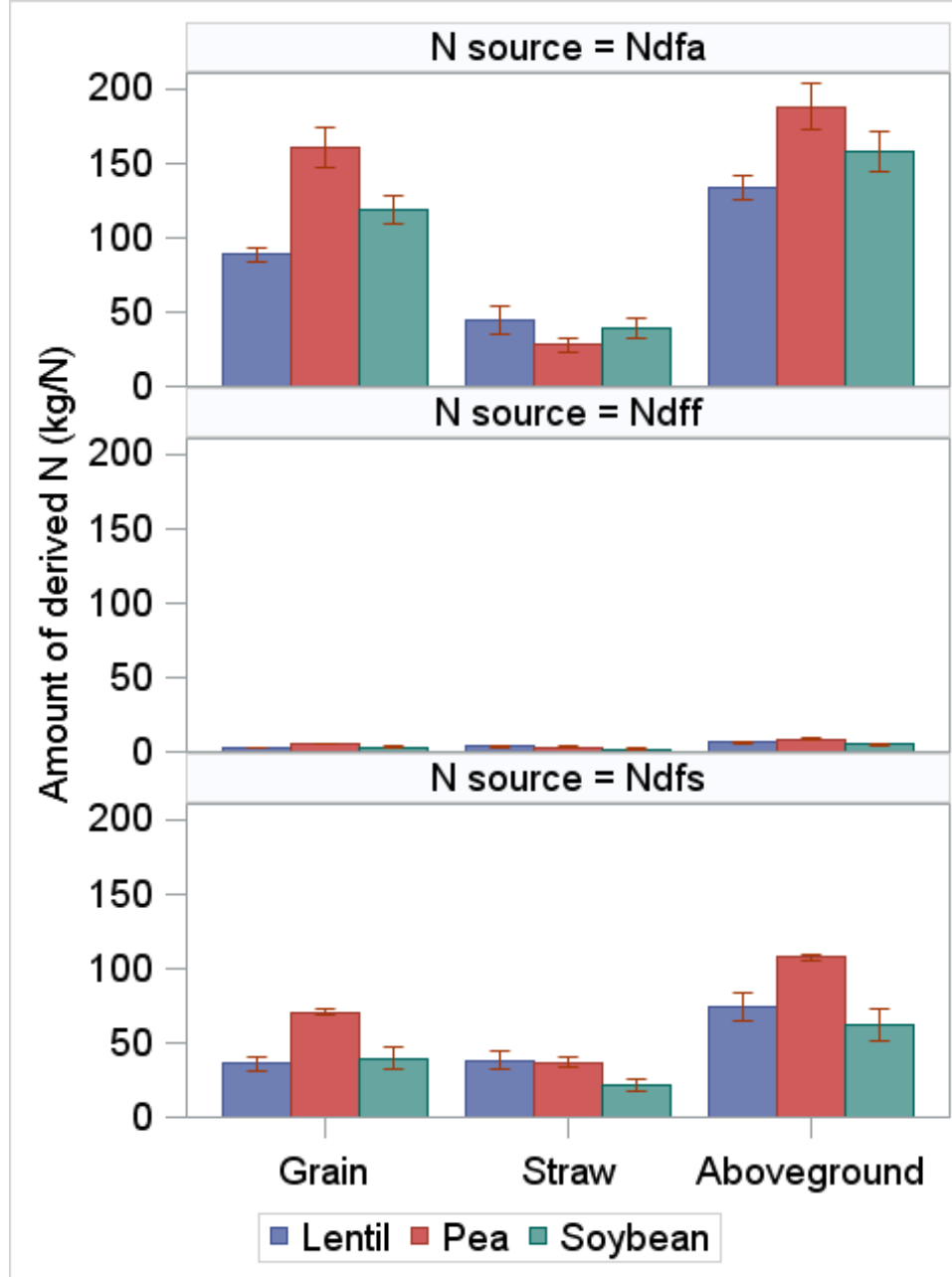


**Percentage of nitrogen derived from atmosphere (%Ndfa) in different crop components in soybean, pea, and lentil.**

**Grain: soybean > lentil ≥ pea**

**Straw: soybean > lentil > pea**





## Grain

**Ndfa:**

pea > soybean > lentil

**Ndfs:**

pea > soybean > lentil

**Ndff:**

pea > soybean > lentil

## Straw

**Ndfa ≈ Ndfs ≈ Ndff**

## Aboveground

**Ndfa:**

pea ≈ soybean ≥ lentil

**Ndff:**

pea > soybean ≈ lentil

**Ndfs:**

pea > lentil ≥ soybean

**N derived from air (Ndfa), N derived from fertilizer (Ndff), and N derived from soil (Ndfs) for soybean, pea, and lentil at Rosthern site.**

**Yield, N and P uptake in following wheat crop**



## Yield, N and P uptake in wheat in 2015 (2-1).

| Site      | Previous crop | Previous crop variety | Yield               |        | N uptake              |         | P uptake              |        |
|-----------|---------------|-----------------------|---------------------|--------|-----------------------|---------|-----------------------|--------|
|           |               |                       | Grain               | Straw  | Grain                 | Straw   | Grain                 | Straw  |
|           |               |                       | kg ha <sup>-1</sup> |        | kg N ha <sup>-1</sup> |         | kg P ha <sup>-1</sup> |        |
| Rosthern  | Soybean       | P001T34R              | 3052 bc             | 3639 a | 65.9 b                | 16.8 a  | 13.8 ab               | 1.3 ab |
|           |               | TH3303R2Y             | 2905 c              | 3396 a | 64.2 b                | 18.0 a  | 13.3 ab               | 1.7 ab |
|           |               | NSC Moosomin          | 3093 abc            | 3749 a | 67.9 b                | 18.2 a  | 13.8 ab               | 1.4 ab |
|           | Pea           | CDC Meadow            | 3183 abc            | 3744 a | 72.2 ab               | 19.4 a  | 14.4 ab               | 1.0 ab |
|           |               | CDC Amarillo          | 2742 c              | 4236 a | 60.4 b                | 25.0 a  | 12.5 b                | 2.3 a  |
|           |               | CDC Limerick          | 3193 abc            | 3846 a | 73.3 ab               | 22.3 a  | 14.0 ab               | 1.8 ab |
|           | Lentil        | CDC Impower           | 3191 abc            | 3924 a | 72.1 ab               | 18.3 a  | 13.6 ab               | 0.6 b  |
|           |               | CDC Invincible        | 3642 ab             | 4056 a | 83.4 a                | 21.0 a  | 15.2 ab               | 0.9 ab |
|           |               | CDC Maxim             | 3746 a              | 4016 a | 85.7 a                | 20.1 a  | 16.2 a                | 1.0 ab |
| Saskatoon | Soybean       | P001T34R              | 2097 a              | 2208 a | 45.1 b                | 7.3 b   | 9.4 b                 | 1.9 a  |
|           |               | TH3303R2Y             | 2629 a              | 2705 a | 59.9 ab               | 13.4 ab | 13.0 ab               | 2.9 a  |
|           |               | NSC Moosomin          | 2706 a              | 2907 a | 64.0 ab               | 13.3 ab | 13.5 ab               | 2.8 a  |
|           | Pea           | CDC Meadow            | 2925 a              | 2972 a | 66.4 ab               | 15.4 a  | 14.2 a                | 2.5 a  |
|           |               | CDC Amarillo          | 2850 a              | 3236 a | 64.4 ab               | 14.7 a  | 13.9 ab               | 2.1 a  |
|           |               | CDC Limerick          | 3044 a              | 3323 a | 71.5 a                | 16.5 a  | 14.8 a                | 2.5 a  |
|           | Lentil        | CDC Impower           | 2886 a              | 3016 a | 65.8 ab               | 13.4 ab | 13.7 ab               | 2.3 a  |
|           |               | CDC Invincible        | 3098 a              | 3184 a | 73.7 a                | 15.3 a  | 14.8 a                | 2.2 a  |
|           |               | CDC Maxim             | 2889 a              | 2880 a | 66.6 ab               | 13.9 ab | 14.0 ab               | 2.3 a  |

† At the Yorkton site presented values are of canola, whereas at the other sites presented values are of wheat.



## Yield, N and P uptake in wheat (canola at Yorkton) in 2015 (2-2).

| Site                 | Previous<br>s crop | Previous crop<br>variety | Yield               |        | N uptake              |        | P uptake              |       |
|----------------------|--------------------|--------------------------|---------------------|--------|-----------------------|--------|-----------------------|-------|
|                      |                    |                          | Grain               | Straw  | Grain                 | Straw  | Grain                 | Straw |
|                      |                    |                          | kg ha <sup>-1</sup> |        | kg N ha <sup>-1</sup> |        | kg P ha <sup>-1</sup> |       |
| Scott                | Soybean            | P001T34R                 | 4775 a              | 3703 a | 111.8 a               | 19.9 a | 16.3 a                | 1.3 a |
|                      |                    | TH3303R2Y                | 3830 a              | 3009 a | 86.3 a                | 17.5 a | 14.3 a                | 1.3 a |
|                      |                    | NSC Moosomin             | 4636 a              | 3574 a | 107.4 a               | 18.0 a | 16.3 a                | 1.1 a |
|                      | Pea                | CDC Meadow               | 4331 a              | 3277 a | 103.3 a               | 17.2 a | 14.9 a                | 0.9 a |
|                      |                    | CDC Amarillo             | 3998 a              | 2992 a | 93.7 a                | 16.3 a | 13.8 a                | 0.9 a |
|                      |                    | CDC Limerick             | 3909 a              | 2870 a | 93.9 a                | 15.8 a | 14.1 a                | 0.9 a |
|                      | Lentil             | CDC Impower              | 4354 a              | 3257 a | 105.0 a               | 15.9 a | 14.4 a                | 0.8 a |
|                      |                    | CDC Invincible           | 4944 a              | 3582 a | 118.1 a               | 18.2 a | 16.5 a                | 0.9 a |
|                      |                    | CDC Maxim                | 4465 a              | 3418 a | 105.5 a               | 18.3 a | 14.9 a                | 1.0 a |
| Yorkton <sup>†</sup> | Soybean            | P001T34R                 | 1851 a              | 5306 a | 50.5 a                | 23.6 a | 12.9 a                | 1.8 a |
|                      |                    | TH3303R2Y                | 1750 a              | 5219 a | 50.6 a                | 21.7 a | 13.3 a                | 2.8 a |
|                      |                    | NSC Moosomin             | 1911 a              | 5167 a | 53.7 a                | 18.2 a | 13.6 a                | 2.1 a |
|                      | Pea                | CDC Meadow               | 1786 a              | 5012 a | 50.9 a                | 23.0 a | 12.9 a                | 1.7 a |
|                      |                    | CDC Amarillo             | 1983 a              | 6010 a | 55.8 a                | 20.5 a | 14.8 a                | 1.6 a |
|                      |                    | CDC Limerick             | 2278 a              | 5952 a | 68.2 a                | 24.3 a | 16.3 a                | 2.0 a |
|                      | Lentil             | CDC Impower              | 2054 a              | 5861 a | 62.9 a                | 24.6 a | 15.9 a                | 2.3 a |
|                      |                    | CDC Invincible           | 2017 a              | 5214 a | 55.8 a                | 24.1 a | 14.5 a                | 2.7 a |
|                      |                    | CDC Maxim                | 2349 a              | 6338 a | 62.1 a                | 19.7 a | 16.1 a                | 1.8 a |

<sup>†</sup> At the Yorkton site presented values are of canola, whereas at the other sites presented values are of wheat.



# Conclusions





- The three short-season varieties of soybean (P001T34R, TH3303R2Y, NSC Moonsomin) had medium grain and straw yield compared to pea and lentil under Saskatchewan soil-climatic conditions in this study;
- Soybean had medium to high N and P uptake compared to pea and lentil.

- N derived from N fixation comprised over 60% of total plant N, and soybean had the highest proportion of Ndfa in total above-ground plant biomass compared to pea and lentil.
- The pattern of amount of N derived from N fixation at the Rosthern site was pea > soybean  $\geq$  lentil.
- At maturity, the majority of fixed N was retained in the grain component, especially for pea and to a lesser extent soybean.
- The three grain legume crops had similar amounts of straw N yield, implying similar N contribution to the soil N pool and succeeding crops in rotation from residue of these crops.



- In the following crop (wheat, canola) grown on soybean, pea, and lentil stubble, similar grain and straw yields were observed among the pulse stubbles.
- N and P uptake in the following crops were also similar among soybean, pea, and lentil stubble.
- These results suggest that nutrient credits for a crop following soybean are not greatly different from pea and lentil.
- Greater P uptake and removal by soybean in grain harvest compared to other pulses does indicate greater potential for P depletion over long-term.

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